PNEUMATICS COURSE FOR VOCATIONAL TRAINING

Work book

A text book from

FESTO DIDACTIC

Pneumatics

PNEUMATICS COURSE FOR VOCATIONAL TRAINING

Work book

A text book from

FESTO DIDACTIC

1st-edition

Printed in W. Germany
Reviser: Rolf Gänger

ISBN 3-8127-0051-4

Preface

This book is part of the comprehensive educational training documentation of the Federal German Institute for Vocational Training Research (BBF) in the Federal German Institute for Vocational Training (BIBB) of the Federal Republic of Germany.

It is the task of the Institute to promote inter alia educational technologies. In this connection the teaching equipment as proven in many years of service is further developed with regard to contents and methods employed, and new teaching equipment is designed and issued. Using large-scale experimental models, multimedia systems have been and are being developed and tested. The media which originate in this way allow optimum training results to be obtained. They permit the application of various teaching methods and a variable use of hardware. Thus it is possible to work with this material both in specialist theory and in specialist practice.

The self-governing body of the BIBB is composed of representatives of the Federal German and "Land" ministries, and of employers' and employees' representatives. All interests are thus protected and optimum working conditions for research, development and production are guaranteed.

FESTO DIDACTIC has gained the licencing rights for foreign language editions and for sales outside the Federal Republic of Germany. Thus, it is to be possible to support vocational education in all areas where the experiences gained over a century in systematic vocational training have hitherto never been compiled so comprehensively nor in such a well-tested way.

Index

Index

Test Questions

Physical Principles

Name: _____

Date: _____

1. Write down the four most important physical quantities and the associated units.

   ..... in .....

   ..... in .....

   ..... in .....

   ..... in .....

2. What is the unit of force called in the SI system and what is the associated unit symbol?

   The unit of force in the SI system is called .

   .....

   The unit symbol is .....

3. What is the formula for pressure p? Use the standardized expressions.

   $p =$

4. The unit of pressure $10 \frac{N}{cm^2}$ has a specific name.

   $10 \frac{N}{cm^2} = 1$

5. Convert the following:

   1.013 bar = ... kPa (psi)

   980 mbar = ... Pa (psi)

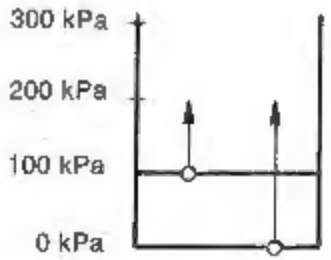
   0.4 bar = ... Pa (psi)

   1040 mbar = ... MPa (psi)

6. Select the correct statements applicable to absolute pressure.

   - ☐ The air pressure given in the daily weather report is indicated as an absolute pressure.
   - ☐ Absolute pressure is the pressure prevailing at the absolute zero pressure point.
   - ☐ Absolute pressure is measured from the absolute zero pressure point.
   - ☐ Absolute pressure is $p_n = 101.3$ kPa (1.013 bar/14.688 psi).
   - ☐ None of the above statements is exactly applicable.

7. Enter into the sketch the terms
   - p_e
   - fluctuating atmospheric pressure line
   - p_{abs}
   - absolute zero pressure



8. State the two gases which are the main constituents of air.

   Air consists mainly of .....

   and .....

9. Complete the following sentence:

   If air is heated in an open bottle, then .....

   .....

10. Complete the following sentence properly. It's a matter of pressure.
    If a contained volume of air is heated, then

    .....

11. In a closed vessel of $V_1 = 60$ dm³, air is contained with a pressure $p_{1abs} = 700$ kPa (7 bar/101.5 psi).
    The temperature is $T_1 = 280$ K (≙ 7° C).The temperature rises to $T_2 = 300$ K (≙ 27° C).

    What is the new pressure in the same vessel?

    $$\frac{p_{1abs} \times V_1}{T_1} = \frac{p_{2abs} \times V_2}{T_2}$$

12 Select the correct statement concerning the standard condition of gases. Several statements are correct.

- ☐ The standard condition of gases refers to a pressure defined by DIN Standards and a defined temperature.
- ☐ The standard condition is defined in D N 1343.
- ☐ Standard condition means normal condition. The usual state of gases at 20° C.
- ☐ Standard condition means $p_n = 101.3$ kPa (1 013 bar/14 688 ps) and $T_n = 273.15$ K

13 Complete the following sentence to give a correct statement

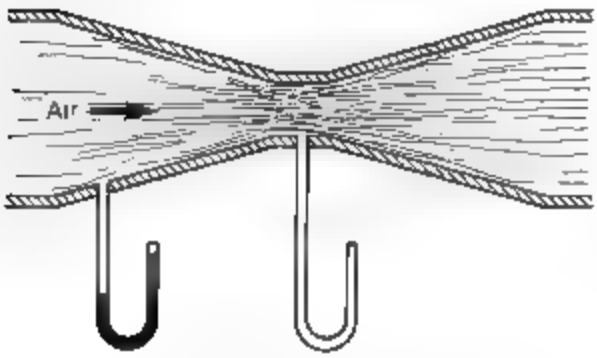
If a gas which is under pressure is expanded,

then

14. Select the statement which best describes how condensed water occurs

- ☐ Condensed water occurs as a result of the moisture in the air forming drops.
- ☐ Condensed water occurs when air saturated with water vapour is cooled down
- ☐ Condensed water occurs by cooling down saturated air

15 Complete the sketch such that the levels of the two liquid columns correspond to the physically correct condition.

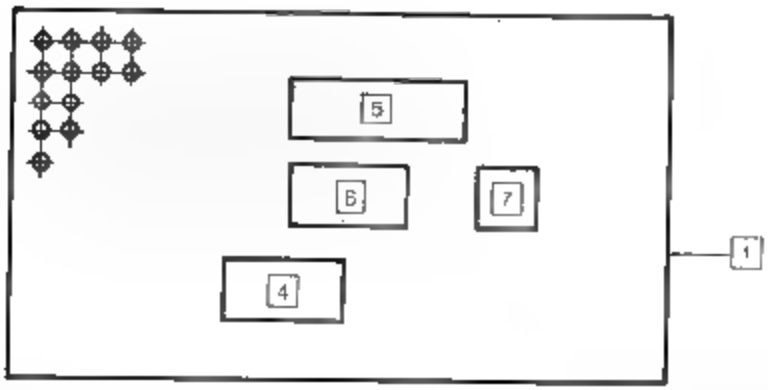


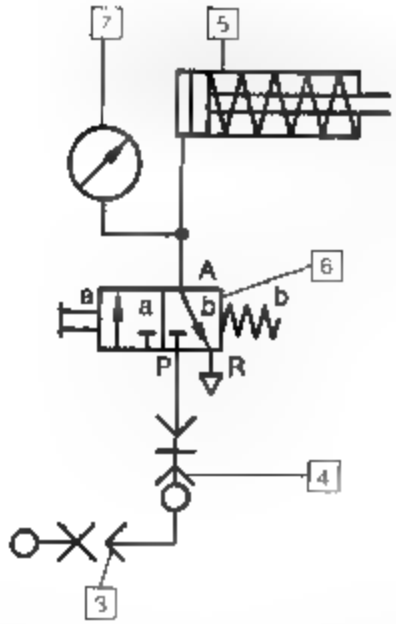
16 Enter in the sketch the position at which the velocity of flow is a maximum

2. Exercise 1

Problem

Machined components are to be ejected from a machine. Solve the problem with the equipment provided. Inform yourself first of all, however, from the next few pages about the construction, the function and the purpose of the devices used.





Procedure

1 Prepare the equipment
2 Insert the single-acting cylinder
3 Insert the 3/2-way valve and the other elements
4 Connect the pneumatic devices with tubing
5 Establish the compressed air connection
6 Operate the 3/2-way valve
7 Dismantle, tidy up

Compressed air supply connection P
Working line A
Exhaust R

The number given on the plug-in board correspond to the equipment.
The connecting tubes may not have any kinks.
When using side valves (Chap. 2.6) with quick-sealing couplings, the exhaust port R must be opened by means of an inserted tube or a silencer.
The manifold and the necessary quick couplings [4] will not be listed again in the following exercises.

Equipment

[1] Plug-in board
[2] Tool (knife or scissors) connecting tubing with threaded connectors
[3] Pressure connection point and connecting line
[4] Quick coupling and manifold
[5] Single-acting cylinder
[6] 3/2-way valve, normally closed
[7] Pressure gauge

Safety

Securely plug in pneumatic devices.
Keep piston rod travel free.
All threaded connectors must be checked before connecting the compressed air, because connecting tubes which become disconnected when compressed air is applied can lead to accidents.
When uncoupling the quick coupling, the end piece of the connecting tube on connections to which compressed air is applied must be held firmly. Accident risk!

Test Questions to Exercise 1

Single-Acting Cylinder
3/2-Way Valve, Normally Closed

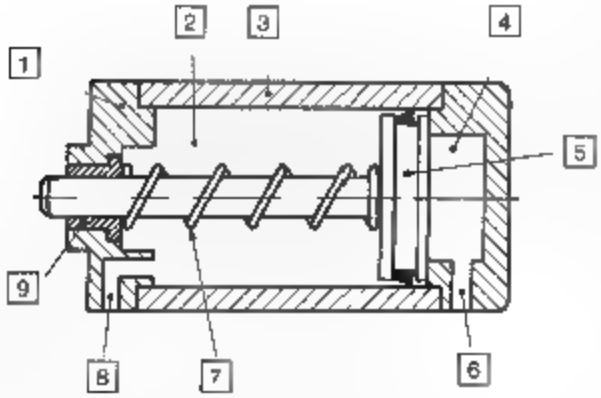
Name: _____

Date: _____

1 The direction of motion of pneumatic cylinders is

2 Draw the symbol of a single-acting cylinder

3 Put in the missing designations.



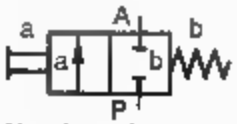
1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____

4. Give three examples of application for single-acting cylinders.

5. Why is the stroke length of a single-acting cylinder limited? Select the correct statement. The stroke length of a single-acting cylinder is limited because
- ☐ pressure is applied to only one side of the piston
- ☐ the opposing force of the compression spring is high
- ☐ the compressed spring takes up a lot of space
- ☐ none of the above statements is correct.

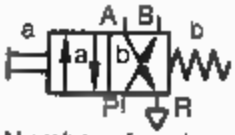
6 Why does the piston rod chamber require a vent? Select the correct answers. The piston rod chamber requires a vent
- ☐ to avoid an air cushion from occurring
- ☐ because air must flow around it for cooling
- ☐ to allow the displaced air to escape
- ☐ none of these answers is correct

7 What are the valves called that are represented by the following symbols:



Number of ports

Number of control positions

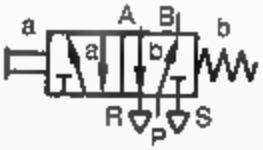


Number of ports

Number of control positions

Number of ports

Number of control positions



Number of ports

Number of control positions ...

8 What do the capital letters on valves signify?

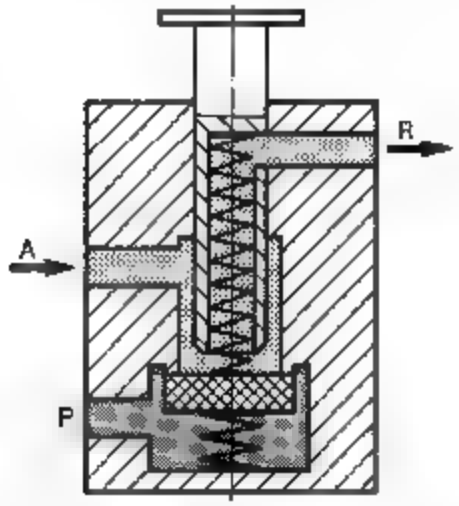
A, B

P

R, S

9 The drawing shows a 3/2-way valve. In which position is the valve?

- ☐ Normal position
- ☐ Mid position
- ☐ Open position



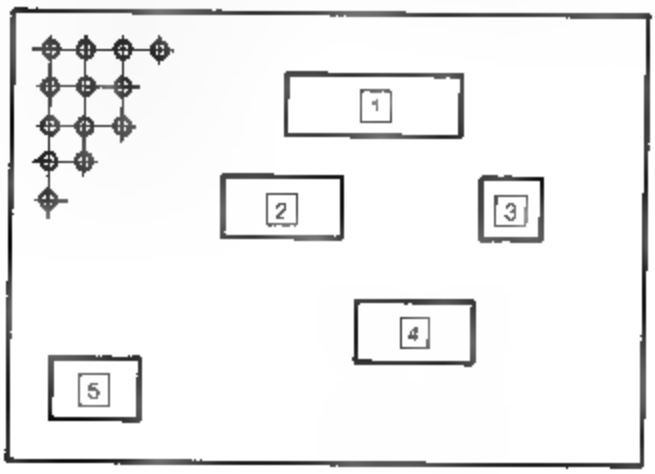
10. What is the symbol for the valve shown alongside? Complete the symbol.

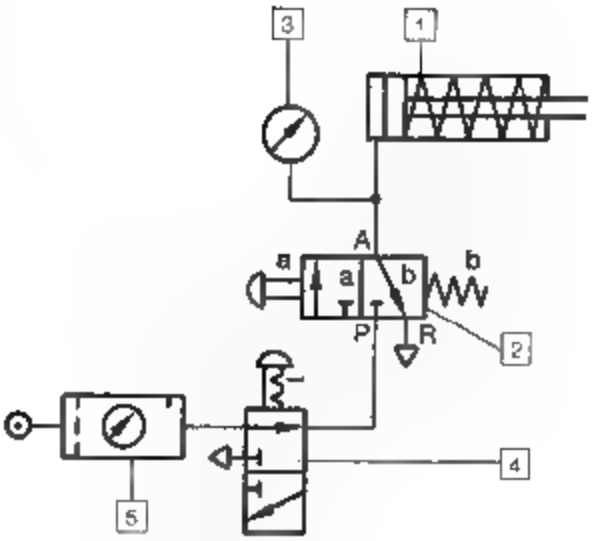
11 Give some examples of application for 3/2-way valves.

3. Exercise 2

Problem

A service unit is to be set properly for a control. You should however first of all inform yourself from the following pages about the construction, the function and the purpose of a service unit.





Procedure

1 Prepare the equipment
2 Mount the components
3 Connect properly
4 Set the regulator to operating pressure
5 Set the lubricator
6 Check the oil flow ahead of the vent hole on the 3/2-way valve by operating (≈50 times)
7 Dismantle, tidy up

Notes

The plug-in board, the tool and the connecting tubes will be required in all other exercises. These items will not be specified particularly from this point onwards.
The correct setting of the lubricator can be checked as follows:
A white piece of paper is held 5 cm away from the exhaust port R.
After operating the valve about 50 times, one should be able to see a fine oil stain on the paper.
The valve silencer must be removed for this.

Equipment

1 Single-acting cylinder
2 3/2-way valve, normally closed (⊂/⋀⋀,
3 Pressure gauge
4 3/2-way valve for on-off (energy supply)
5 Service unit

Safety

Do not exceed the maximum pressure range of the service unit.

Test Questions to Exercise 2

Name: _____

Service Unit

Date: _____

1 You are given the following devices: filter, filter with water trap, pressure regulator, pressure gauge, lubricator. Allocate these to the respective functions given below. Note that some functions are listed which do not correspond to the devices given above.

Hold pressure constant

Clean air

Reduce pressure to preset value

Moisten air

Provide pressure indication

Enrich air with oil mist

Shut off pressure

Measure air flow

Filter air and remove condensate

2 Draw the simplified symbol for a service unit.

3. What is the purpose of the lubricator?
- ☐ to clean the air by means of an oil mist
- ☐ to combine water with oil in order to extract water from the air
- ☐ to enrich the air with an oil mist in order to lubricate the moving parts
- ☐ to trap particles of dirt by the oil mist and collect them in the bowl of the lubricator

4. In which sequence is air handled in a service unit?
Label the sequence by the numbers 1, 2, 3.

Reduce pressure to a constant preset value

Clean the air of dust and dirt and remove water

Enrich the air with an oil mist

5 What is the most obvious difference in appearance between filter and lubricator?
- ☐ the size
- ☐ the drip dome (sight glass) on the lubricator
- ☐ water collects at the bottom of the filter
- ☐ oil can be seen as the visible liquid in the lubricator

6. What does the symbol for a lubricator look like?

7 Draw the symbol for a pressure gauge

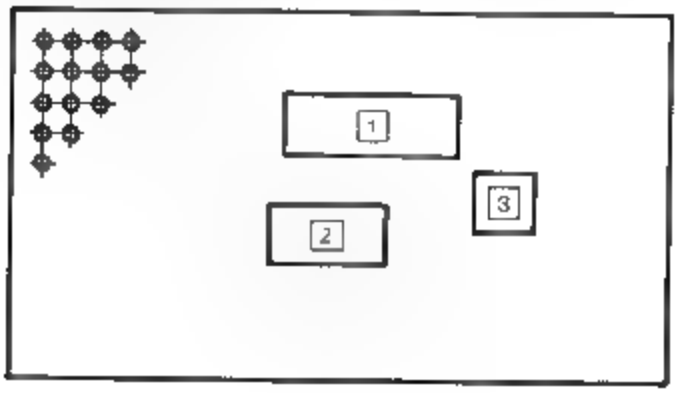
8 Which component part of the pressure gauge converts the pressure to be measured to a movement?
- ☐ Tube spring
- ☐ Lever
- ☐ Pointer
- ☐ Gear rack segment and pinion

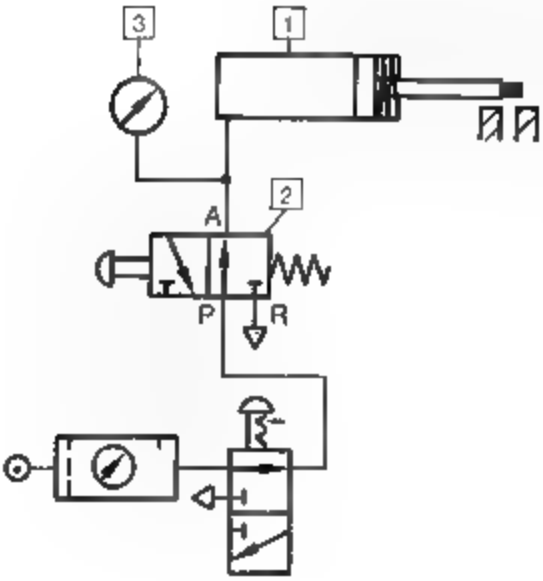
9 Where should the service unit be arranged in the pneumatic system?
- ☐ immediately in front of each working element
- ☐ immediately after the air compressor
- ☐ immediately in front of each pneumatic system

4. Exercise 3

Problem

A slide is to release a tool opening on pushing a button, and close again immediately after releasing the button. Try to solve the problem with the equipment listed below. Inform yourself beforehand, however, about the normally open 3/2-way valve.





Procedure

1 Prepare the equipment
2 Mount the single-acting cylinder on the plug-in board
3. Mount the 3/2-way valve on the plug-in board
4. Connect the pneumatic devices
5. Establish the compressed air supply
6. Operate the 3/2-way valve
7 Dismantle, tidy up

Note

The 3/2-way valve has the following ports:
Compressed air supply port P
Working line A
Exhaust R

Equipment

1 Single-acting cylinder
2 3/2-way valve, normally open
3 Pressure gauge

Safety

Plug in pneumatic devices securely

Keep piston rod travel free.

All threaded connectors must be rechecked before establishing the compressed air supply because connecting tubes which disconnect due to the compressed air can cause accidents

When detaching the quick coupling, the end piece of the connecting tube in connections under pressure must be held firmly because of the danger of recoil.

Test Questions to Exercise 3

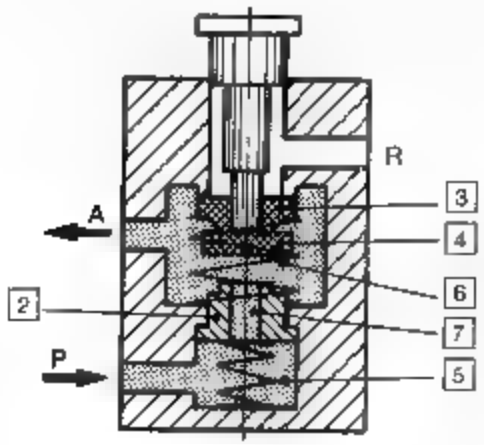
Name: _____

3/2-Way Valve, Normally Open

Date: _____

1 Arrange the following subfunctions such that they result in the function of a normally open 3/2-way valve (poppet valve). Be quite clear first about the working sequence without paying any attention to the subfunctions. Then write them down line by line.

Valve disc is moved against spring [6] / plunger is pressed / supply flow from P is interrupted / A to R is open / part [2] is moved against spring [5] / shouldered pin contacts valve disc [3] / valve disc [4] closes bore [7]



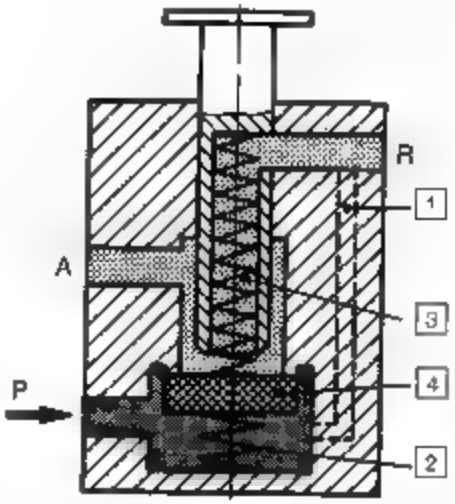
2 Draw the symbol for a normally open 3/2-way valve

3 Give an example of application for a normally open 3/2-way valve

4 What changes are necessary to make a normally open 3/2-way valve from a normally closed 3/2-way valve (slide valve type)?

5 Tick off the reason why the normally closed 3/2-way valve (poppet valve type) shown here cannot be converted to a normally open valve by interchanging ports P and R.

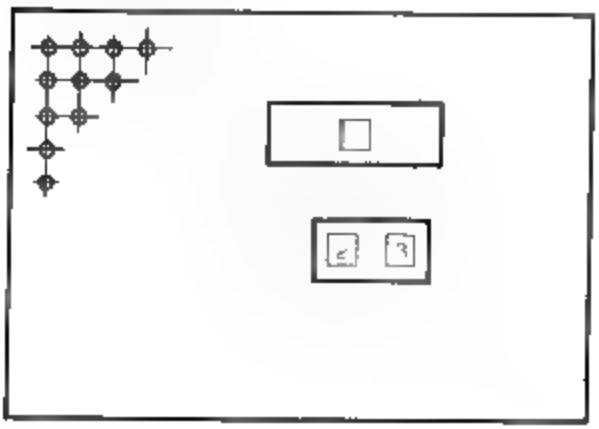
- ☐ Bore [1] missing in housing
- ☐ Valve disc spring [2] is too weak
- ☐ Plunger spring [3] is too strong, valve disc lifts off
- ☐ Opening of the valve seat [4] by air pressure

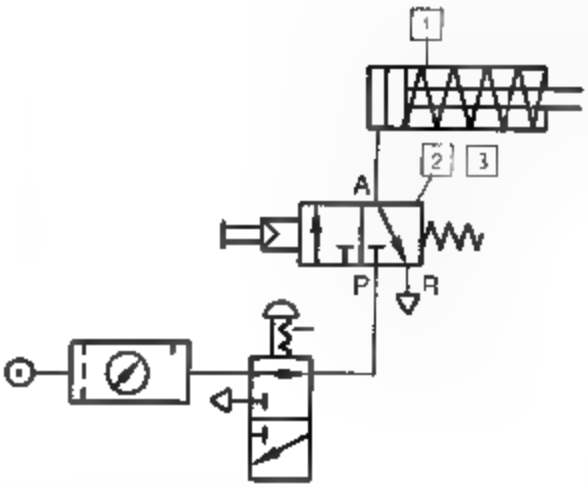


5. Exercise 4

Problem

A pin is to be pressed in by means of a single-acting cylinder. Owing to the switching frequency the valve operating force should be as small as possible.
Inform yourself in the next few pages about the construction and function of the devices used





Procedure

1. Prepare the equipment
2. Mount the parts
3. Connect properly
4. Operate the 3/2-way valve (several times)
5. Replace the piloted valve by a directly controlled valve
6. Compare the switching forces by operating the directly controlled valve
7. Install the piloted valve
8. The instructor should set the compressed air to $p_e \approx 150$ kPa (1.5 bar/21.75 psi). Operate the 3/2-way valve. Discuss the observations with the instructor
9. Dismantle, tidy up

Notes

By converting the normally closed 3/2-way valve shown here, one obtains a normally open 3/2-way valve. After slackening the two socket head cap screws, the housing head is turned through 180° and again screwed firmly

Equipment

- 1 Single-acting cylinder
- 2 Piloted normally closed 3/2-way valve
  or
- 3 Directly controlled 3/2-way valve (see Exercise one)

Safety

Check working pressure p_e = 400 ... 600 kPa (4 ... 6 bar/58 ... 87 psi)

All threaded connectors must be checked before connecting the compressed air supply because connecting tubes which become disconnected by compressed air can cause accidents.

When detaching the quick coupling, the end piece of the connecting tube with connections under pressure must be held firmly because of the recoil risk

Test Questions to Exercise 4

Name: _____

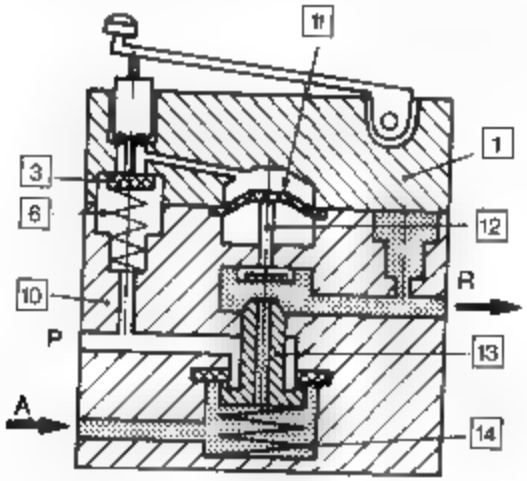
3/2-Way Valve, Piloted

Date: _____

1 Which reason is applicable?
The pilot control makes the switching forces small because

- ☐ in effect, two valves are coupled
- ☐ the valve disc surface of the pilot valve is relatively small
- ☐ the working pressure of the pilot valve is not fully effective
- ☐ the spring forces are low owing to the use of small springs

2 Write down the functional sequence of a pilot controlled normally closed 3/2-way valve. Make use of the preformulated subfunctions.
Valve plunger [12] closes valve seat sleeve [13] and presses compression spring [14] together.
Working pressure is applied to diaphragm [11].
Control stud pushes valve disc [3] open.
P to A is thus opened.



3 Why does a piloted valve no longer function with a working pressure of p = 150 kPa (1.5 bar/21.75 psi)?

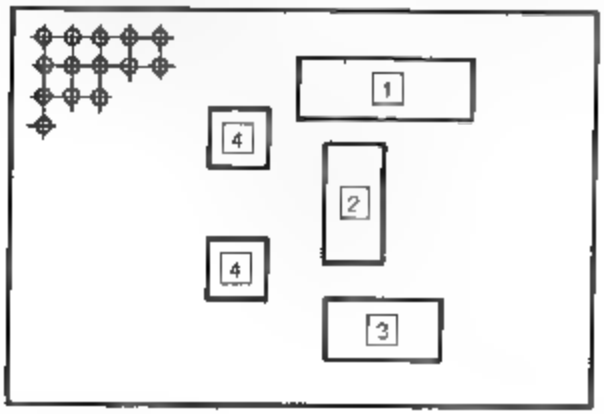
- ☐ The pressure drop in the pipeline is too great
- ☐ The guide sleeve does not seal because the acting force is too low
- ☐ The service unit does not transmit such a low working pressure
- ☐ The force due to the working pressure is not sufficient to extend the valve plunger

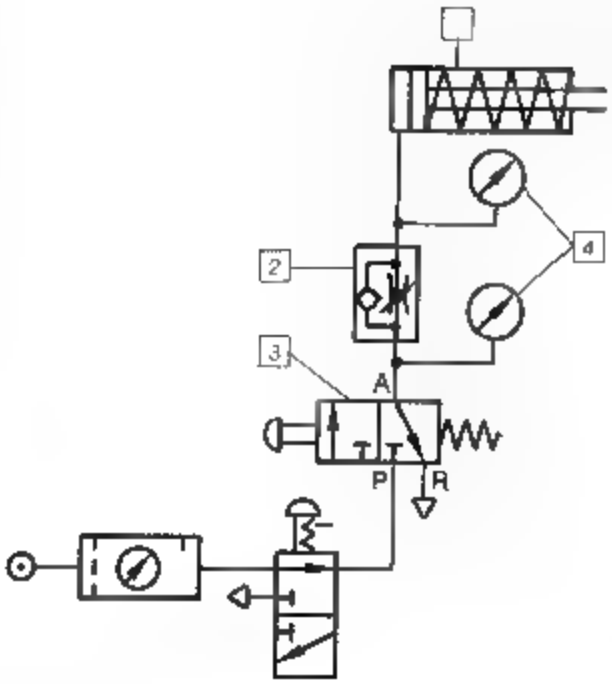
4 Draw the symbol of a normally open, piloted 3/2-way valve.

6. Exercise 5

Problem

The single-acting cylinder is to travel out slowly in order to avoid damaging the plastic pin which is to be pressed in. The outward stroke speed of the cylinder is to be adjustable. Solve the problem using the specified equipment and procedure. But first inform yourself from the next few pages about the construction and the principle of operation of a one-way flow control valve.





Procedure

1. Prepare the equipment
2. Mount the parts
3. Connect properly
4. Check the function of the cylinder and directional control valve by operating the directional control valve
5. Turn the regulating screw on the one-way flow control valve
6. Check whether the outward stroke speed can be controlled
7. Set various piston rod speeds
8. Dismantle, tidy up

Notes

The outward stroke speed of the piston must be adjustable. It is therefore necessary to ensure that the one-way flow control valve is connected properly (direction of arrow = throttling direction).

Tighten each locknut after setting the regulating screw.

Never tighten the regulating screw with force (damage to the valve), and also never unscrew it completely when working pressure is applied. Otherwise it will fly out. Accident risk!

Equipment

1. Single-acting cylinder
2. One-way flow control valve
3. Normally closed 3/2-way valve
4. 2 pressure gauges

Safety

Keep the piston traverse free. Mount devices securely.

Before connecting the compressed air supply, all threaded connections should be checked because connecting tubes which disconnect under compressed air can cause accidents.
When uncoupling the quick coupling, the end piece of the connecting tube with connections under pressure must be held tight because of the recoil risk.

Do not completely unscrew the regulating screw (see notes).

Test Questions to Exercise 5

Name: _____

Date: _____

One-Way Flow Control Valve

1 From which two devices is a one-way flow control valve bu lt?

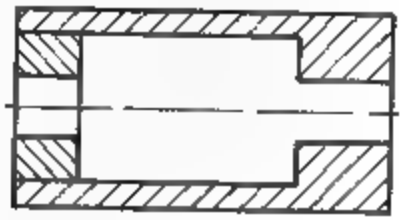
a)

b)

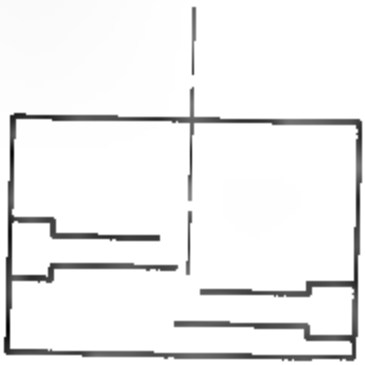
2. Draw the symbols for the devices from wh ch the one-way flow control valve is built

3. Draw the symbo for a variable one-way flow contro valve.

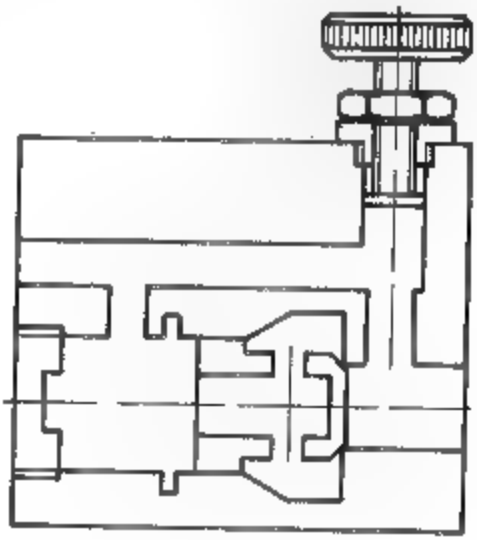
4. Complete the drawing of a spring-loaded check valve



5. Complete the drawing of the variable flow control valve



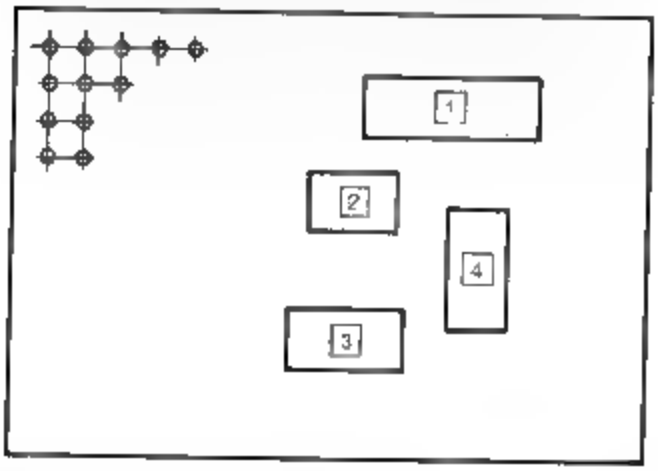
6 Complete the drawing of the var able one-way flow control valve

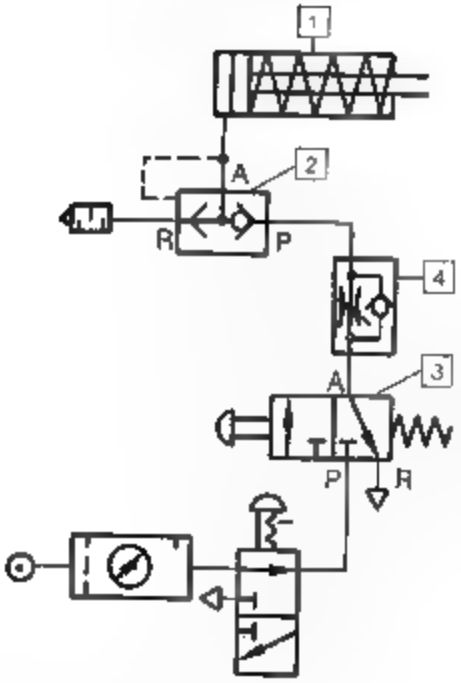


7. Exercise 6

Problem

The single-act ng cylinder is to return to ts initial position very quickly after the pin has been pressed in. To accomp sh this, the cylinder must be linked to a quick exhaust valve such that the p ston side is exhausted as quickly as possible. To reduce the exhaust noise from the quick exhaust va ve, a silencer is to be used





Procedure

1. Prepare the equ pment
2. Mount the parts and connect properly
3. Check the function by operating the valve
4. Set the flow control valve such that the piston rod has travelled out to its full extent in 1 to 2 seconds
5. Compare the time of the outward and return strokes by measurement, if necessary estimate the return time
6. Remove the s lencer and check the difference in noise level when exhaust occurs
7. Remove the quick exhaust valve and compare the times for the outward and return strokes
8. Dismant e, tidy up

Notes

The quick exhaust valve must be connected properly. Port A is connected with the cylinder. Port P is connected with the pressure source through a flow control valve and a 3/2-way valve.

Connect the quick exhaust valve with the cylinder by means of a double n pple or a very short p ece of tubing.

Equipment

- 1 Single-acting cylinder
- 2 Quick exhaust valve with silencer
- 3 Normally closed 3/2-way valve
- 4 One-way flow control valve
- 5 Stop watch

Safety

At stage no 6 in the procedure, the cylinder exhaust escapes to the atmosphere in a burst' for this reason, it should not be directed towards the eyes. The sudden decompression of the air is accompanied by an explosive noise which can shock people.

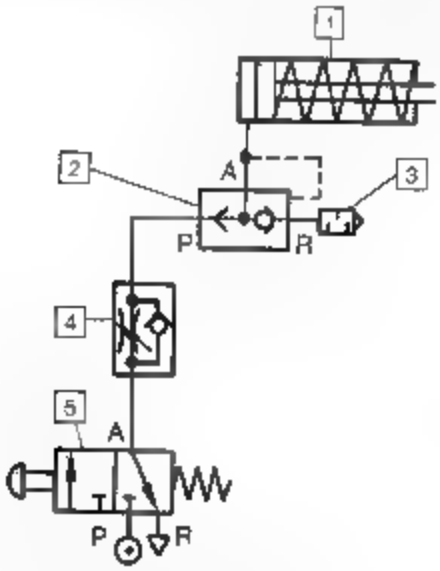
When uncoupling the quick coupl ng, the end piece of the connecting tube with connectors subjected to pressure must be held tightly because of the recoil r sk

Test Questions to Exercise 6

Quick Exhaust Valve
Silencer

Name: _____
Date: _____

1 In the circuit diagram below, symbols of pneumatic devices are labelled with numbers. The standard names for these are to be entered in the table below.



1 _____
2 _____
3 _____
4 _____
5 _____

2. In the cross-sectional views of the quick exhaust valve shown below, the ports are to be labelled (numbers, directional arrows) and the position of the sealing ring is to be drawn in for the following conditions:

Fig ① way P → A open, outlet R closed

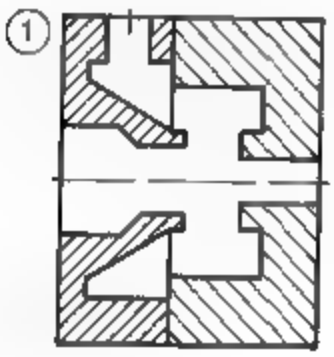
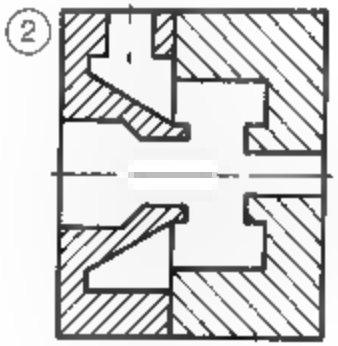


Fig ② way A → R open, air supply port P pressureless



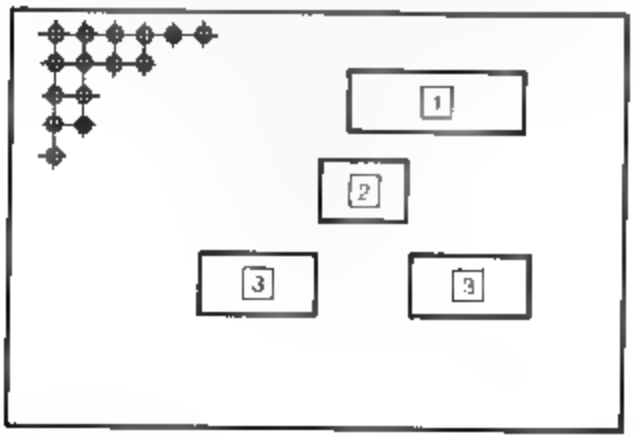
3. What is the purpose of a quick exhaust valve?
- ☐ Quick exhaust of cylinders and tubes
- ☐ Quick exhaust of compressors
- ☐ In emergencies, the quick exhaust valve exhausts the entire pipeline system

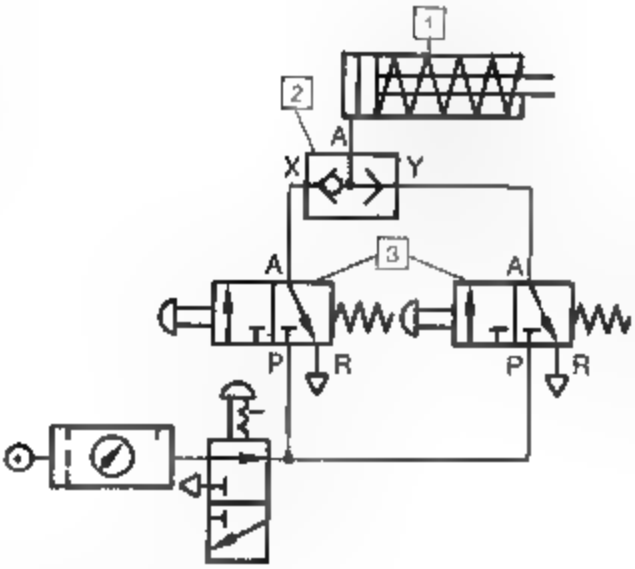
4 Which is the correct description of the principle of operation of a silencer?
- ☐ The exhaust air entering the silencer is distributed over a large surface area. The speed of the air is reduced by its flowing past the sintered particles contained in labyrinth style in the damping material
- ☐ The silencer throttles the exhaust air by the sintered particles which it contains. The exhaust noise is thus also reduced.
- ☐ The exhaust air entering the silencer is retained by the plastic particles arranged in labyrinth style and therefore cannot release the exhaust noise to the outside

8. Exercise 7

Problem

A single-acting cyl nder is to be operated through a shuttle va ve by two different 3/2-way valves





Procedure

1 Prepare the equipment
2 Mount the parts
3. Connect properly
4 Check the function of the circuit by alternately operating the two directional control valves
5 Check whether the piston travels out if both valves are operated at the same time
6. Dismantle tidy up

Note

The shuttle valve is also designated as a logic OR. If a signal is present at X **or** Y, A gives an output signal.

Equipment

1 Single-acting cylinder
2 Shuttle valve
3 Two 3/2-way valves, normally closed (⊄/W)

Safety

Connect the compressed air supply only after assembly has been completed.

Keep the piston rod travel free.

All threaded connectors are to be checked before connecting the compressed air supply because connecting tubes which disconnect under pressure can cause accidents.

Test Questions to Exercise 7

Name: _____

Shuttle Valve **Date:** _____

1 Draw the symbol for a shuttle valve

2 What is the intended purpose of the shuttle valve?

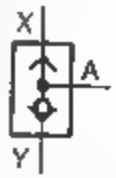
- ☐ It should allow reversal of the piston's direction of movement.
- ☐ It should allow alternate exhausting.
- ☐ It should allow a device to be operated from two different points.
- ☐ It should allow two pneumatic devices to be connected

3 Sketch a cross-sectional view of a shuttle valve

4. Complete the description of the principle of operation of a shuttle valve.

The shuttle valve allows compressed air to flow from the applicable port X or Y to . . The ball is . ... by the air flowing in and . . . . . the opposite port.

5 Through which port in a shuttle valve does the exhaust air escape, if supply air enters through Y and the weight of the ball acts against port Y?



The exhaust air escapes through

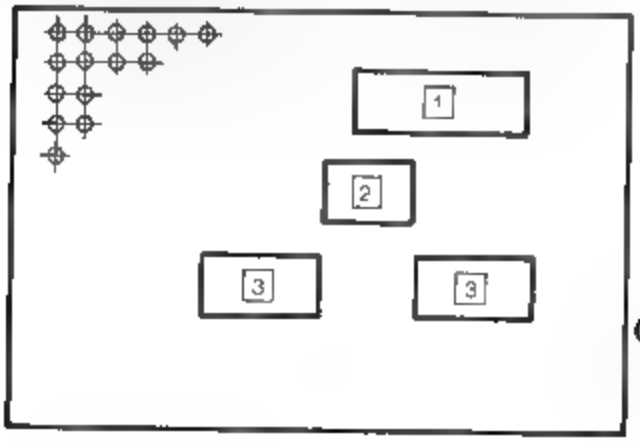
because

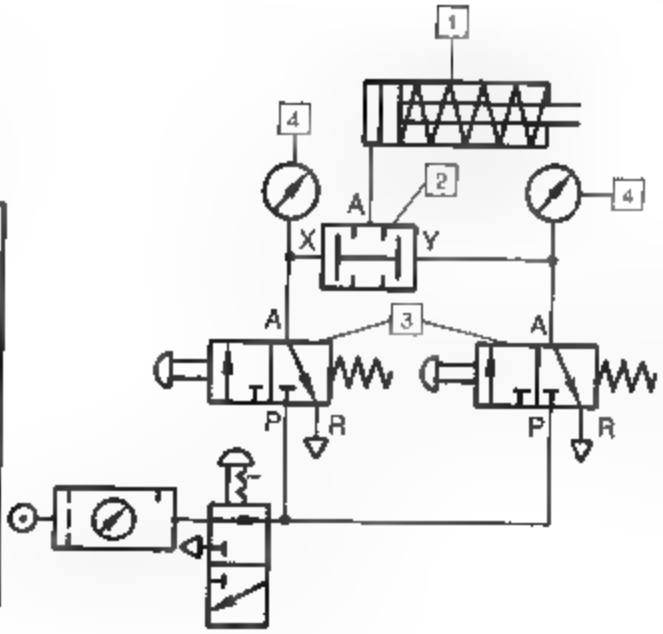
6. Why is the shuttle valve also called an OR valve?

9. Exercise 8

Problem

A single-acting cylinder is to extend only when two 3/2-way valves are operated at the same time.





Procedure

1 Prepare the equipment
2 Mount the parts
3 Connect properly
4 Check the function of the circuit by operating the two directional control valves at the same time
5 Check whether the piston extends when one of the valves is operated
6 Set the pressure reducing valve to p_e = 300 kPa (3 bar/43.5 psi)
7 Loosen connecting tube from port A of the two-pressure valve
8 Operate the 3/2-way valve with both hands and observe the pressure gauges
9 Discuss your observations with the instructor
10 Dismantle, tidy up

Notes

The two-pressure valve is also designated as a logic AND. Only when a signal is applied to X **and** Y does A give an output signal

Equipment

1 Single-acting cylinder
2 Two-pressure valve
3 2 normally closed 3/2-way valves
4 2 pressure gauges

Safety

Do not make the compressed air connections until assembly is completed

Keep the piston rod travel free.

All threaded connectors are to be checked before connecting the compressed air since connecting tubes which recoil due to pressure may cause accidents.

Test Questions to Exercise 8

Name: _____

Two-Pressure Valve

Date: _____

1 Draw the symbol of a two-pressure valve.

2 What is the purpose of a two-pressure valve?

- ☐ It is to trigger the function of a device when actuating two buttons at the same time
- ☐ Two pneumatic devices are to be supplied with pressure at the same time.
- ☐ It is to enable the actuation of a device from two points at the same time
- ☐ It is to enable operation with two pressures.

3 Sketch the cross-section of a two-pressure valve

4 Complete the description of the principle of operation of a two-pressure valve.

First, compressed air flows from Y to the valve.

The port ..... is then supplied with air

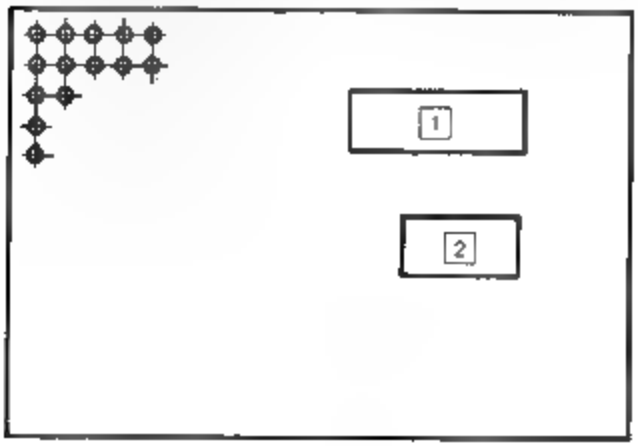
through the port .....

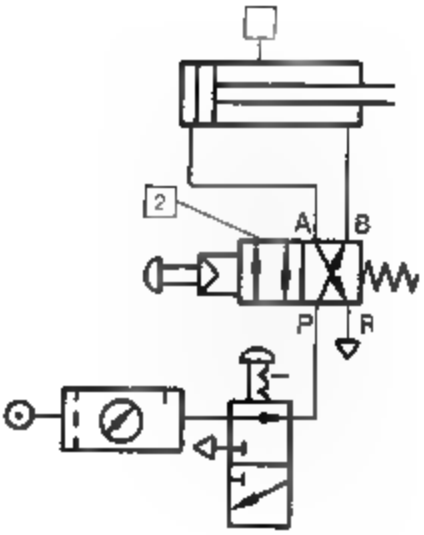
5. Why is the two-pressure valve also called an AND valve?

10. Exercise 9

Problem

A double-acting cy inder is to be connected with a 4/2-way valve such that the piston rod travels out after connecting the compressed air and operating the valve.





Procedure

1. Prepare the equipment
2. Mount the parts
3. Connect properly
4. Check the function by operating the 4/2-way va ve
5. Dismantle, tidy up

Check the working pressure.

If the p ston rod travels out when the compressed air is connected the connecting tubes have been attached incorrectly

Equipment

1 Double-acting cyl nder
2 4/2 way valve
or
5/2-way valve

Safety

Plug n pneumatic devices securely

Keep piston rod travel free

Observe permiss ble pressure.

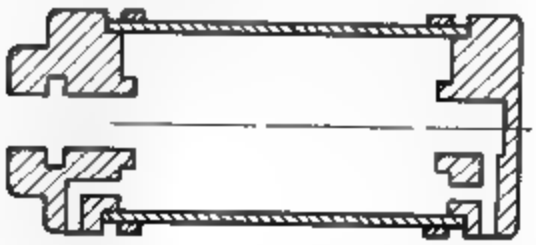
Test Questions to Exercise 9

Double-Acting Cylinder
Piloted 4/2-Way Valve
5/2-Way Valve

Name: _____

Date: _____

1 The piston with piston rod, seals and bearing should be drawn into the drawing below of a double-acting cylinder



2. What advantages and disadvantages does the double-acting cylinder have compared with the single-acting cylinder?

Advantages:

Disadvantages:

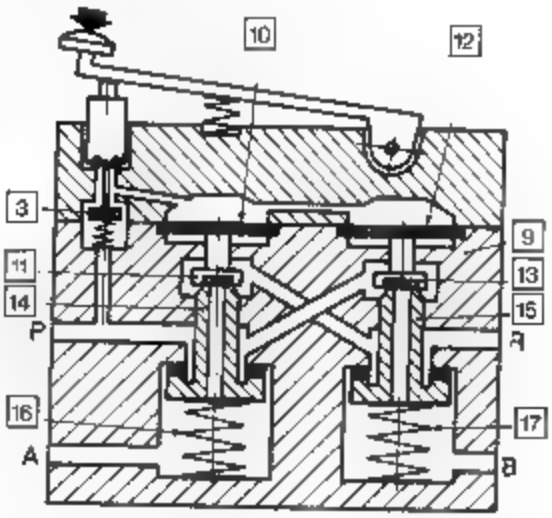
3. Calculate the force when a double-acting cylinder travels out and in (ignoring friction) Piston diameter 32 mm, piston rod diameter 12 mm, at a supply pressure of 600 kPa (6 bar/ 87 psi). Use the back of the sheet for the calculation

4 What is the purpose of 4/2-way valves and 5/2-way valves?

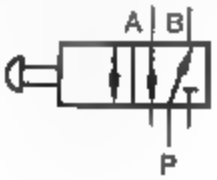
- ☐ These directional control valves control single-acting cylinders (advance and return) and are used in production.
- ☐ These directional control valves control the compressed air with small switching forces, especially with hydraulic drives
- ☐ These directional control valves control double-acting cylinders.
- ☐ None of these statements correctly describes the purpose of piloted 4/2-way valves.

5. Describe the working principle of a piloted 4/2-way valve making use of the subfunctions below

Valve plungers [11] and [13] push down, valve seat sleeves [14] and [15] open P → A and B → R
control stud is operated,
valve disc [3] is pushed down ports P → B and A → R are closed,
diaphragms [10] and [12] are subjected to compressed air



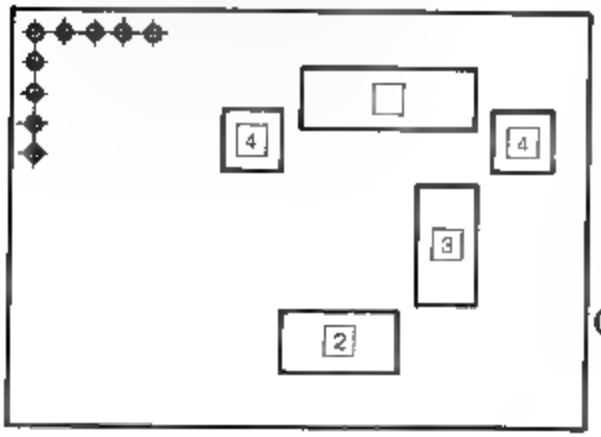
6. Complete the symbol for the 5/2-way valve.

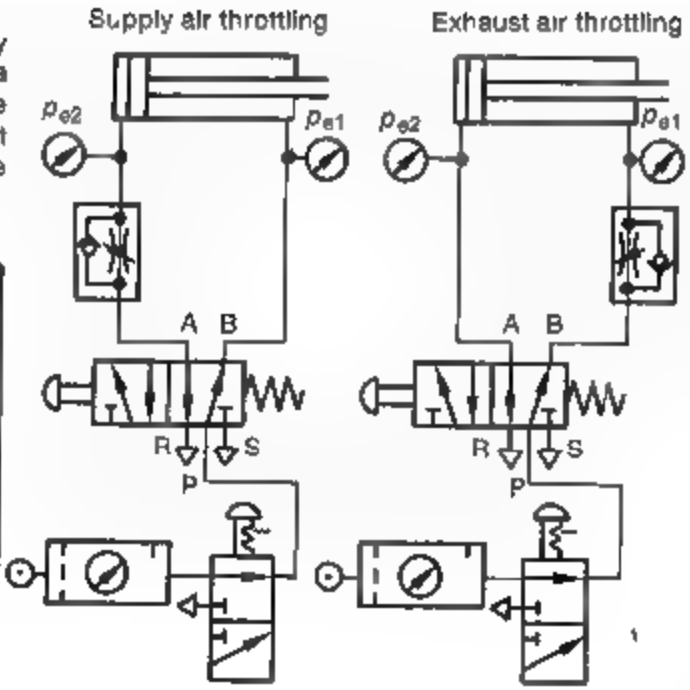


11. Exercise 10

Problem

A 4/2-way valve or 5/2-way valve and a one-way flow control valve are to be connected with a double-acting cylinder in accordance with the circuit diagrams shown below in such a way that the advance of the piston rod is throttled when the directional control valve is actuated





Procedure

1 Prepare the equipment
2. Mount the parts and properly connect the supply air throttling arrangement
3 Check the function of the circuit by operating the directional control valve
4. Set various piston speeds
5 Close off the compressed air supply
6 Connect properly the exhaust air throttling arrangement
7 Set various piston speeds
8 Dismantle, tidy up

The exercise consists of two parts. In the first part, the supply air is throttled, and in the second part the exhaust air. The different effects of the two controls can be seen on the pressure gauges during the piston stroke. Please also note on a sheet of paper the pressures p_{e1} and p_{e2} for each circuit during and after the outward stroke. The values will be required for the test

Equipment

1 Double-acting cylinder
2 4/2-way valve or 5/2-way valve
3 One-way flow control valve
4 2 pressure gauges

Safety

Do not screw out the regulating screw on the one-way flow control valve too far
When converting the control from supply air to exhaust throttling, always disconnect the compressed air
When uncoupling the quick coupling, the end piece of the connecting tube of connections under pressure must be held firmly because of the recoil risk

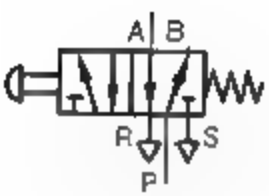
Test Questions to Exercise 10

Supply Air Throttling
Exhaust Air Throttling

Name: _____
Date: _____

1 Draw in the correct position of the one-way flow control valve for supply air throttling

2 Draw in the correct position of the one-way flow control valve for exhaust air throttling



3 State the main feature of exhaust air throttling by completing the following sentence
The pressures which you have measured should help you

Pressure on outward stroke

p_{e1} p_{e2}

kPa (bar/psi) .. kPa (bar/psi)

In exhaust air throttling, the piston is

4 State an area of application for supply air throttling and exhaust air throttling.
Supply air throttling is used mainly with a constant

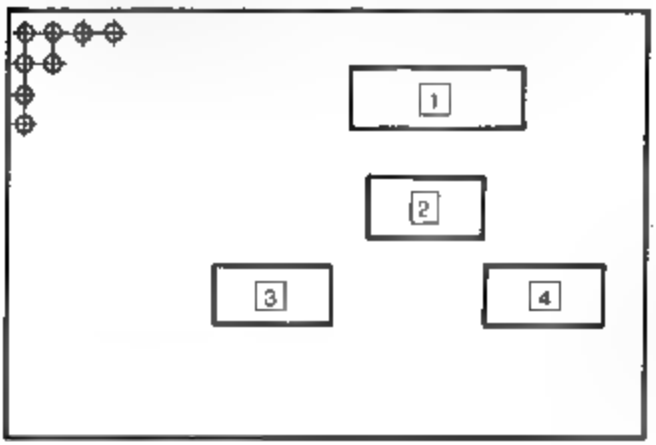
acting against the direction of

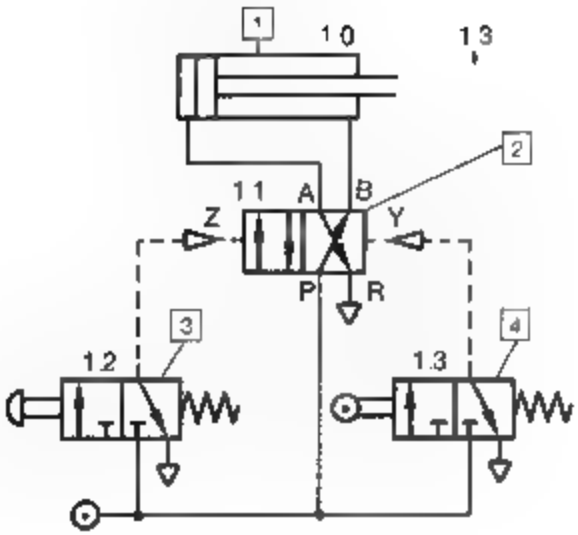
Exhaust air throttling is used mainly where

12. Exercise 11

Problem

A double-acting cylinder is to trave out after operating a pushbutton and, after having traveled out to the ful extent, automatica.y travel in again





Procedure

1 Prepare the equipment
2 Mount the parts
3 Connect properly
4. Check the function by operating the push-button of the 3/2-way valve
5 Dismantle, tidy up

Equipment

1 Double-acting cylinder
2 4/2-way or 5/2-way valve (
3 Normally closed 3/2-way valve (
4 Normally closed 3/2-way valve

Safety

Be careful when switching on the compressed air supply! The present control position of the valve cannot be identified from the outside The piston rod can therefore also move out immed ately after switching on the supply This will be the case if the previous user has dismantled the control with the piston rod n the extended posit on. The devices should therefore be dismantled only when the piston rod is in the retracted position

Note the working pressure:

p_e = 400 kPa 600 kPa (4 bar , 6 bar/ 58 psi . . 87 psi)

Be careful also with the forward movement of the piston rod. It returns on its own.

All threaded connectors should be checked before connecting the compressed air supp y because connecting tubes which become disconnected under pressure can cause accidents

Test Questions to Exercise 11

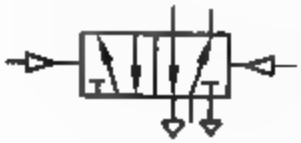
4/2-Way Valve and 5/2-Way Valve
Types of Valve Control-Symbols
Design of a Circuit Diagram

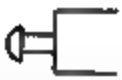
Name: _____

Date: _____

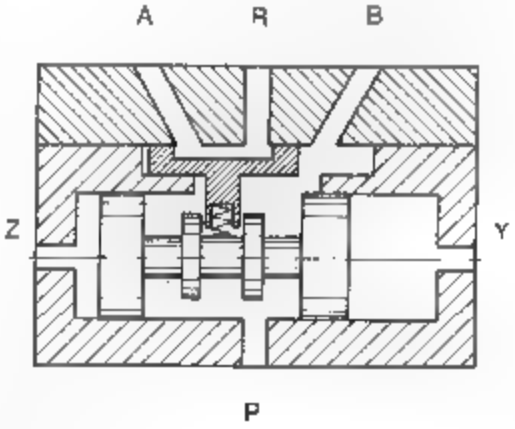
1 Here are 6 symbols and 6 names. Write the correct name beneath each symbol.

Pushbutton; lever; detent; roller lever, roller lever with idle return; 5/2-way valve (impulse valve)





2. Draw in the paths of the compressed air in this control position. Use circles to mark the places on the moving parts which have to be sealed specially



3. What causes the spool in an impulse valve to be moved

- ☐ The compressed air flowing in through P reverses the position of the spool
- ☐ The spool is reversed by the vacuum which arises.
- ☐ The pressure signal produced by the 4/2-way valve reverses the spool
- ☐ The spool is reversed by the force which results from applying compressed air to one of the spool chambers.

4 In which sequence should the devices in a circuit diagram be arranged?

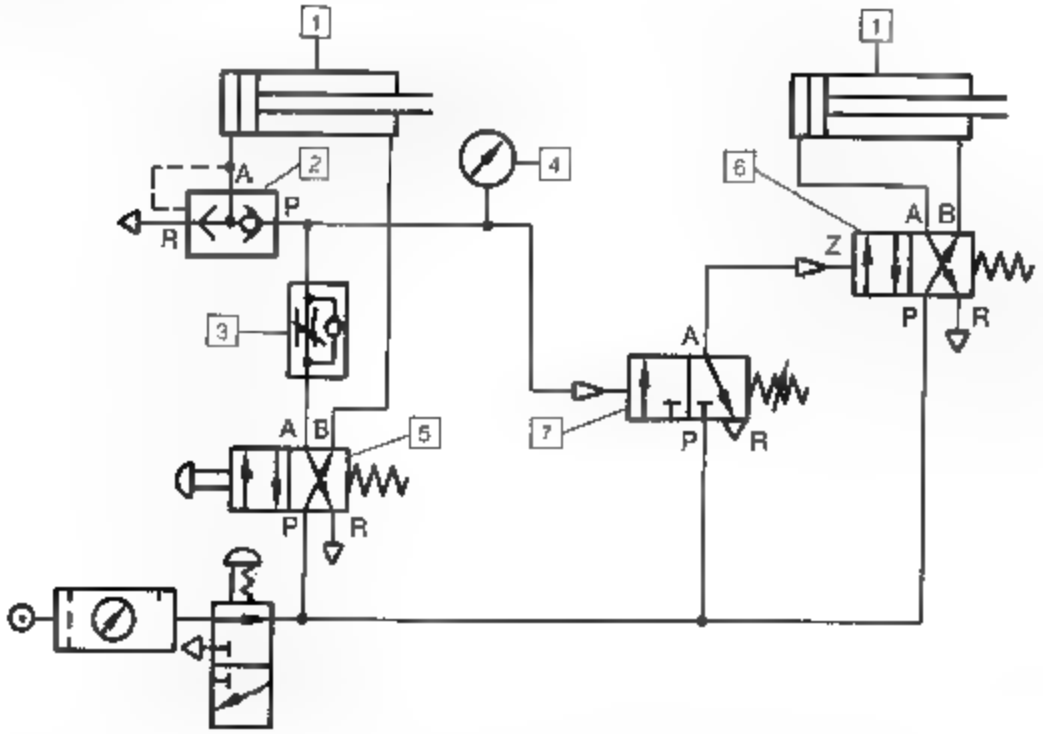
5 Draw a circuit diagram for the following function

After the compressed air supply has been switched on, a double-acting cylinder is to travel in and out continuously
Use the back of the sheet

13. Exercise 12

Problem

A workpiece is to be fed to a fixture via a magazine and be clamped by a cylinder. After the first cylinder has clamped firmly a second cylinder is to stamp the component.



Procedure

1 Prepare the equipment
2 Mount the parts and connect properly
3 Check the function by operating the 4/2-way valve or 5/2-way valve ( )
Operate once briefly, and then for a longer period and observe the pressure gauge while doing so
4. Reset the spring on the pressure switching valve 7
5 Operate and observe
6. Dismantle, tidy up

Notes

From this exercise on, the plug-in board will no longer be shown. You can now arrange the devices yourself in accordance with the circuit diagram

Equipment

1 2 double-acting cylinders
2 Quick exhaust valve
3 One-way flow control valve
4 Pressure gauge
5 4/2-way valve or 5/2-way valve ( )
6 4/2-way valve or 5/2-way valve ( )
7 3/2-way valve with adjustable control pressure triggering ( )

Safety

Note the working pressure

p_e = 400 kPa . 600 kPa (4 bar 6 bar/ 58 psi ... 87 ps)

All conections must be checked before switching on the compressed air supply, because connecting tubes which become disconnected can cause accidents.

The piston rod paths must be kept free

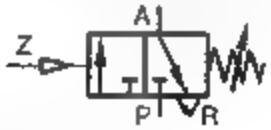
Test Questions to Exercise 12

3/2-Way Valve with Adjustable Control Pressure Triggering

Name: _____

Date: _____

1 Here is the symbol for a 3/2-way valve with adjustable control pressure triggering. Answer the following questions



a) Is the valve open or closed in the normal position?

☐ open
☐ closed

b) What is the meaning of the triangle drawn in this form at outlet R?

c) What is the meaning of the arrow through the spring?

The arrow

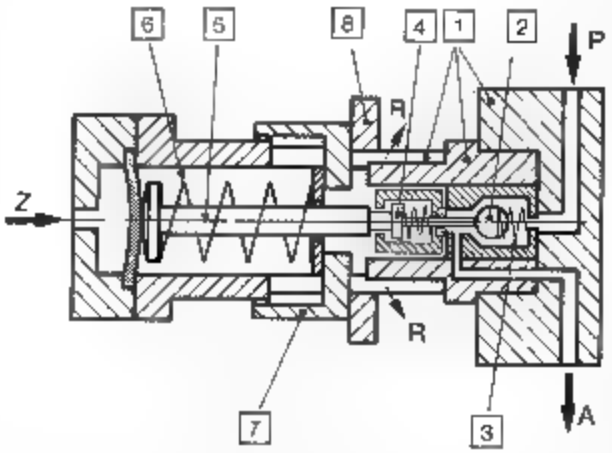
2 The diaphragm surface in a 3/2-way valve with adjustable control pressure triggering is 1.2 cm². The preset spring force is measured as 36 N. To which value must the control pressure rise in order for the valve to reverse? (Note: Pressure equals force divided by area.)

3 What is the function of the O-ring on the valve plunger [4]?

☐ It must seal the way to R when reversal takes place
☐ It must seal the way to A before reversal takes place
☐ It must seal P after reversal takes place.

4 Put in the correct order the functional sequence when the valve closes.

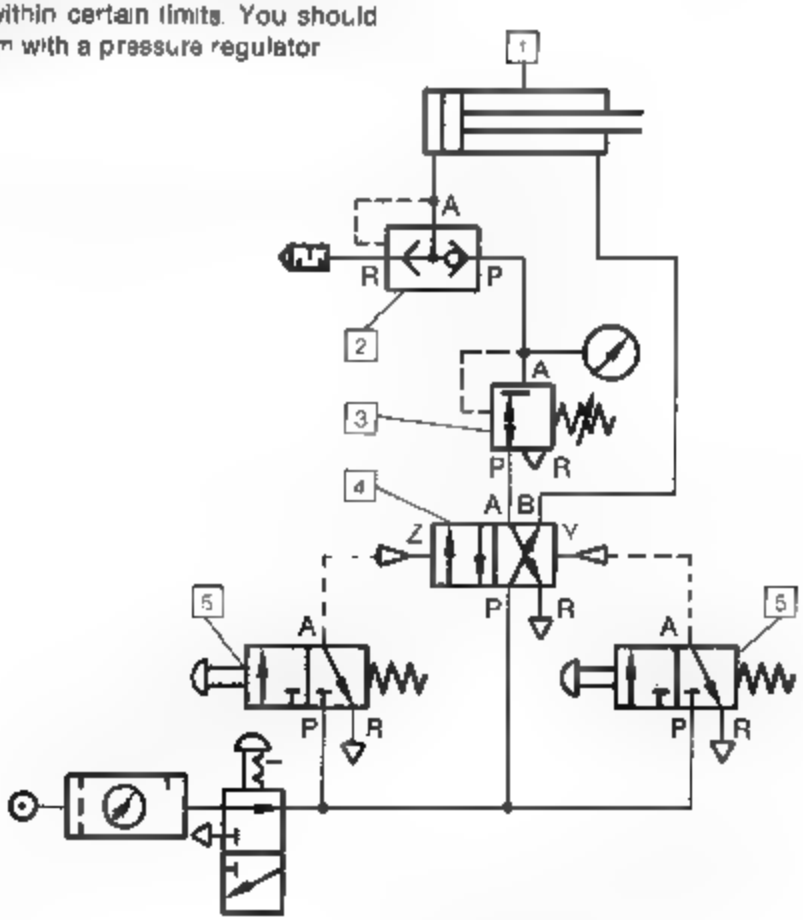
Spring [3] pushes ball [2] back on its seat. / Spring [6] pushes the actuating piston [5] back / Thus, valve plunger [4] also returns under the action of the spring force [3] / P is closed and exhaust is possible from A to R.



14. Exercise 13

Problem

P astic parts are to be stamped with a heated die. The stamp ng force shou d always be constant and adjustable within certain limits. You should solve th s problem with a pressure regulator



Procedure

1. Prepare the equipment
2. Mount the parts and connect properly
3. Check the function by operating the 3/2-way va ves
4. Set the pressure regulator to various values
5. Operate and observe the pressure gauge
6. Dismantle, tidy up

Notes

The piston rod will always travel out when switch ng on the air supply if the previous user switched off the system while the rod was in the extended position and removed the 4/2-way valve or 5/2-way valve, or if the cylinder ports are nterchanged Apart from the quick exhaust function, the quick exhaust valve has the function in this exercise of not al owing the exhaust air to flow through the pressure regu ator

Equipment

- 1 Double-acting cylinder
- 2 Quick exhaust valve
- 3 Pressure regulator with pressure gauge
- 4 4/2-way valve or 5/2-way valve
- 5 Two 3/2-way valves, normally closed

Safety

Note the working pressure:

p_e = 400 kPa ... 600 kPa (4 bar 6 bar/ 58 psi ... 87 psi)

When switching on the compressed air supply make sure that the piston rod can also travel out immediately because the control position of the 4/2-way or 5/2-way valve cannot be seen from the outside.

Keep the piston rod path free

Test Questions to Exercise 13

Relieving Pressure Regulator
(Pressure Reducing Valve)

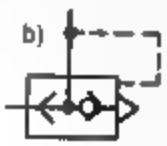
Name: _____

Date: _____

1. Which is the symbol for a relieving pressure regulator to ISO 1219? (Mark with a cross)

a)

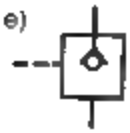
b)



c)

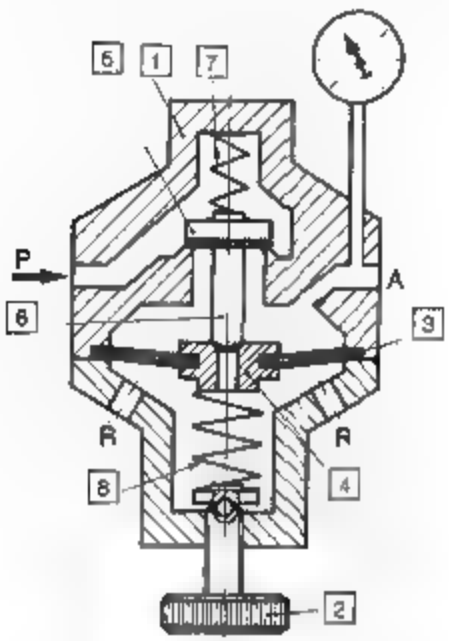
d)

e)



2 What happens if a pressure surge occurs on the secondary side (port A)?

- ☐ Valve plunger [5] opens against compression spring [7]
- ☐ Valve seat ring [4] and diaphragm lift the valve plunger [5] and thus allow flow to occur
- ☐ Spring [8] is compressed by the valve seat ring [4] and the diaphragm [3] thus allowing flow through the bore in [4]



3. Name an example of application for a relieving pressure regulator

4 According to the manufacturer, 150 N are required for working the plastic parts. Unless you have found another value experimentally, add another 10 N for overcoming the friction of the cylinder. To which value must you set your pressure regulator?

Calculation of the cylinder surface area

Cylinder bore d = cm

$$A = \frac{d^2 \times \pi}{4} \quad \text{in cm}^2$$

A =

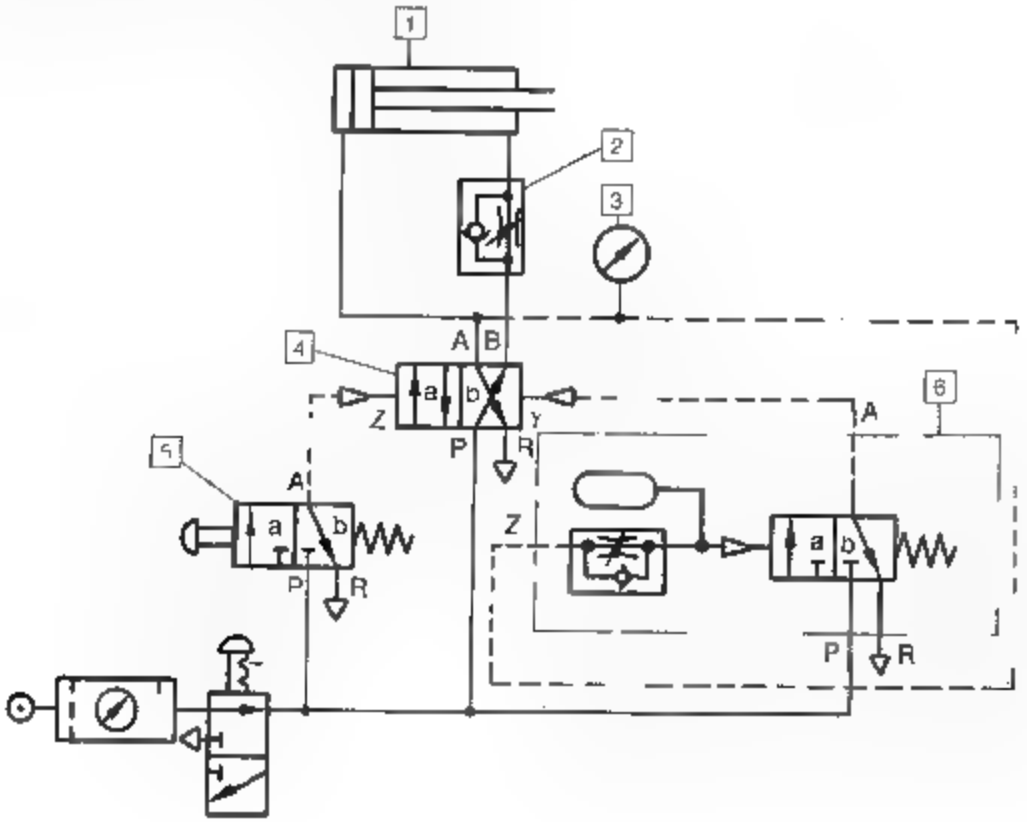
Calculation of setting pressure

p =

15. Exercise 14

Problem

Plastic parts are to be fused together by heat ng whi e at the same time pressing them together The fus ng t me is to be var able because var ous materia thicknesses are processed



Procedure

1 Prepare the equipment
2 Bu ld up in accordance with the circu t d agram and connect properly
3. Check the function by operating the 3/2-way valve
4 Adjust the dwel time on the time de ay va ve
5. Verify with the stop watch whether the dwe l t me is always the same at any one setting
6. Find out between which l mits the dwe l time can be varied
7 Dismantle, tidy up

Equipment

1 Double-acting cylinder
2 One-way flow control valve
3 Pressure gauge
4 4/2 way valve or 5/2 way valve
5 Normally closed 3/2-way valve
6 Normally closed time-delay valve
7 Stop watch

Safety

Note the working pressure:

p_e = 400 kPa 600 kPa (4 bar 6 bar/ 58 psi 87 psi)

Do not get in the way of the piston rod path
Rectify faults on y when the system is switched off ‚ON – OFF‚

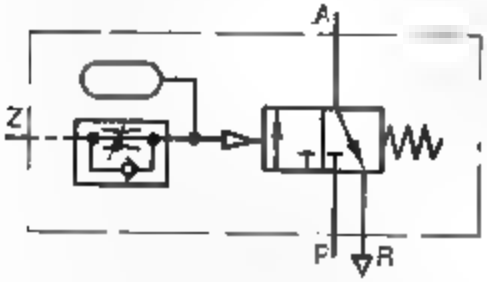
Test Questions to Exercise 14

Name: _____

Time Delay Valve

Date: _____

1 Which three devices make up a time delay valve?



a)

b)

c)

2 What is the meaning of the thin dot-dash lined rectangle in the symbol of the time delay valve?

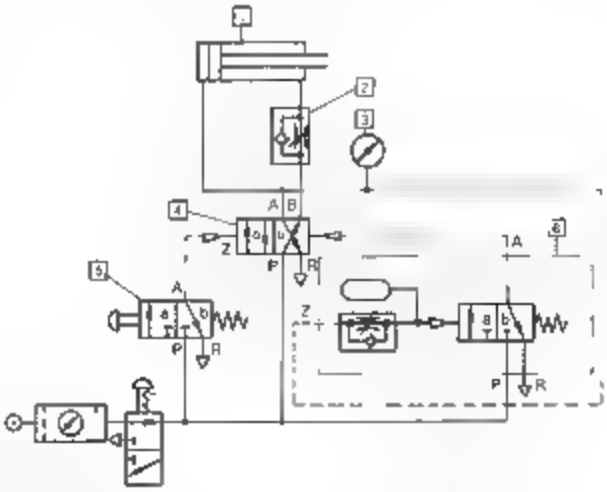
- ☐ Designation of the device
- ☐ Timing elements are represented in this way symbolically
- ☐ Designation of an assembly
- ☐ The device is switched by a control line

3 Which operation allows the time-delayed switching of the time delay valve?

- ☐ The slow non-return action
- ☐ The time-delayed throttling of the check valve
- ☐ The slow build-up of pressure in the capacitor
- ☐ The spring force of the 3/2-way valve

4 Name an example of application for a time delay valve

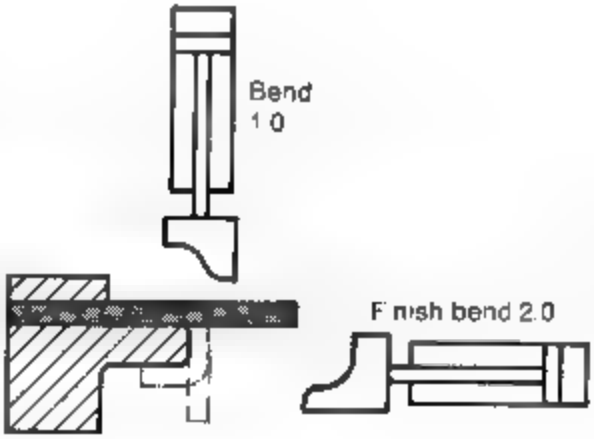
5. What is the function of the various devices in the circuit diagram? Continue the table.



No	Name	Function
1	Cylinder	Pressing
2	One-way flow control valve	Throttles exhaust from 1
3		
4		
5		
6		

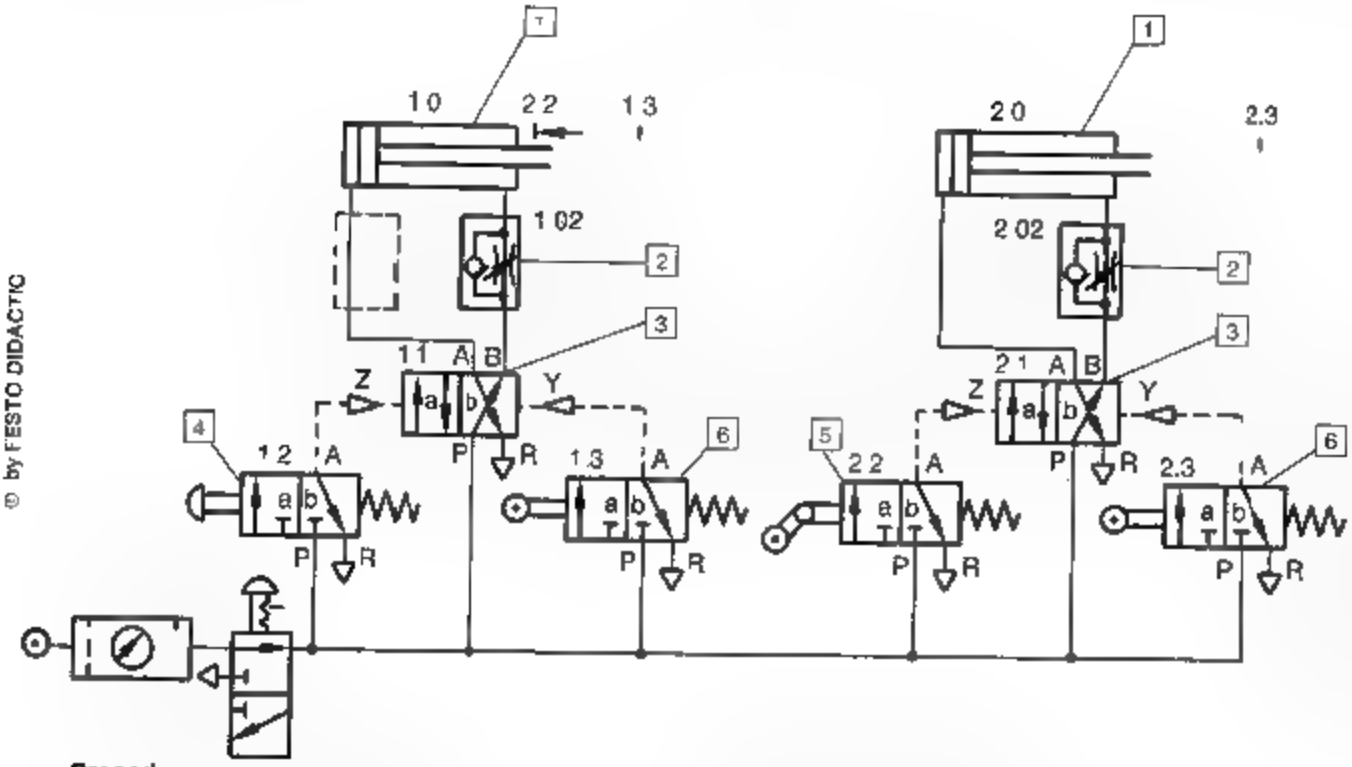
17. Exercise 16

Positional sketch



Problem

Metal sheets are to be flanged on a pneumatically operated bending tool. After the part has been clamped, it is bent by a double-acting cylinder 1.0 and then the finish bend is effected by another double-acting cylinder 2.0. Triggering is by means of a manual pushbutton. The circuit should be designed such that each time a start signal is given one working cycle is performed



Procedure

1. Prepare the equipment
2. Build up in accordance with the circuit diagram
3. Check the function by means of 1.2
4. Convert the circuit for another tool. Cylinder 1.0 is to travel out quickly and travel in slowly. Fit in the return the flow control valve from the advance
5. Throttle more from working cycle to working cycle and observe the control
6. Discuss observations with the instructor
7. Dismantle, tidy up

Notes

The term signal switch-off is explained in Exercise 17

Equipment

- 1 2 double-acting cylinders
- 2 2 one-way flow control valves
- 3 Two 4/2-way valves or 5/2-way valves
- 4 Normally closed 3/2-way valve
- 5 Normally closed 3/2-way valve
- 6 2 normally closed 3/2-way valves

Safety

When searching for faults, never operate the roller levers by hand — danger of crushing!

Test Questions to Exercise 16

Name: _____

Bending Tool

Date: _____

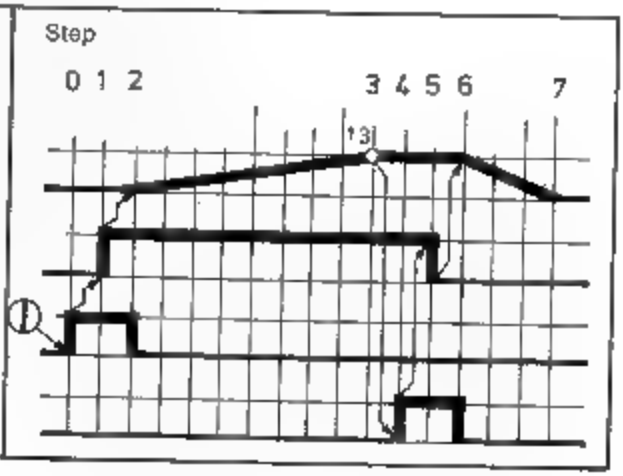
1 Draw the symbol of a normally closed 3/2 way valve with idle return roller and spring return

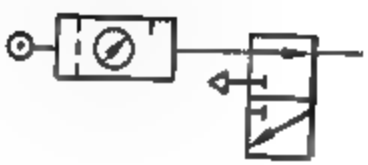
2 What is the advantage of controls with idle return roller valves?

3. Name a disadvantage of controls with idle return roller valves

4 Design the circuit diagram for the following displacement-step diagram

Component		State	
Device No.	Name	Function	Pos.
1.0	Double-acting cylinder	Bending	Out In
1.1	5/2 way valve	Controls 1.0	a b
1.2	3/2 way valve	Controls 1.1	a b
1.3	3/2 way valve	Controls 1.1	a b





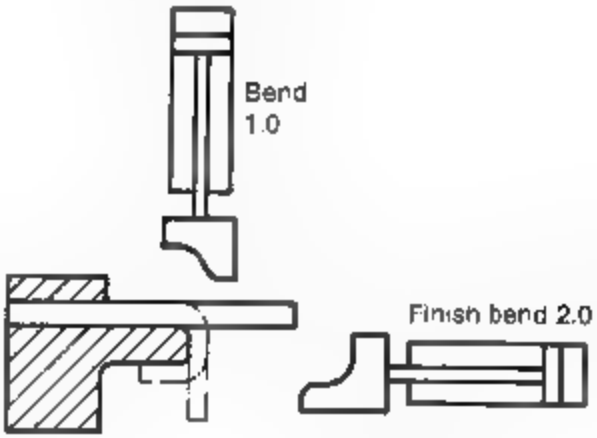
18. Exercise 17

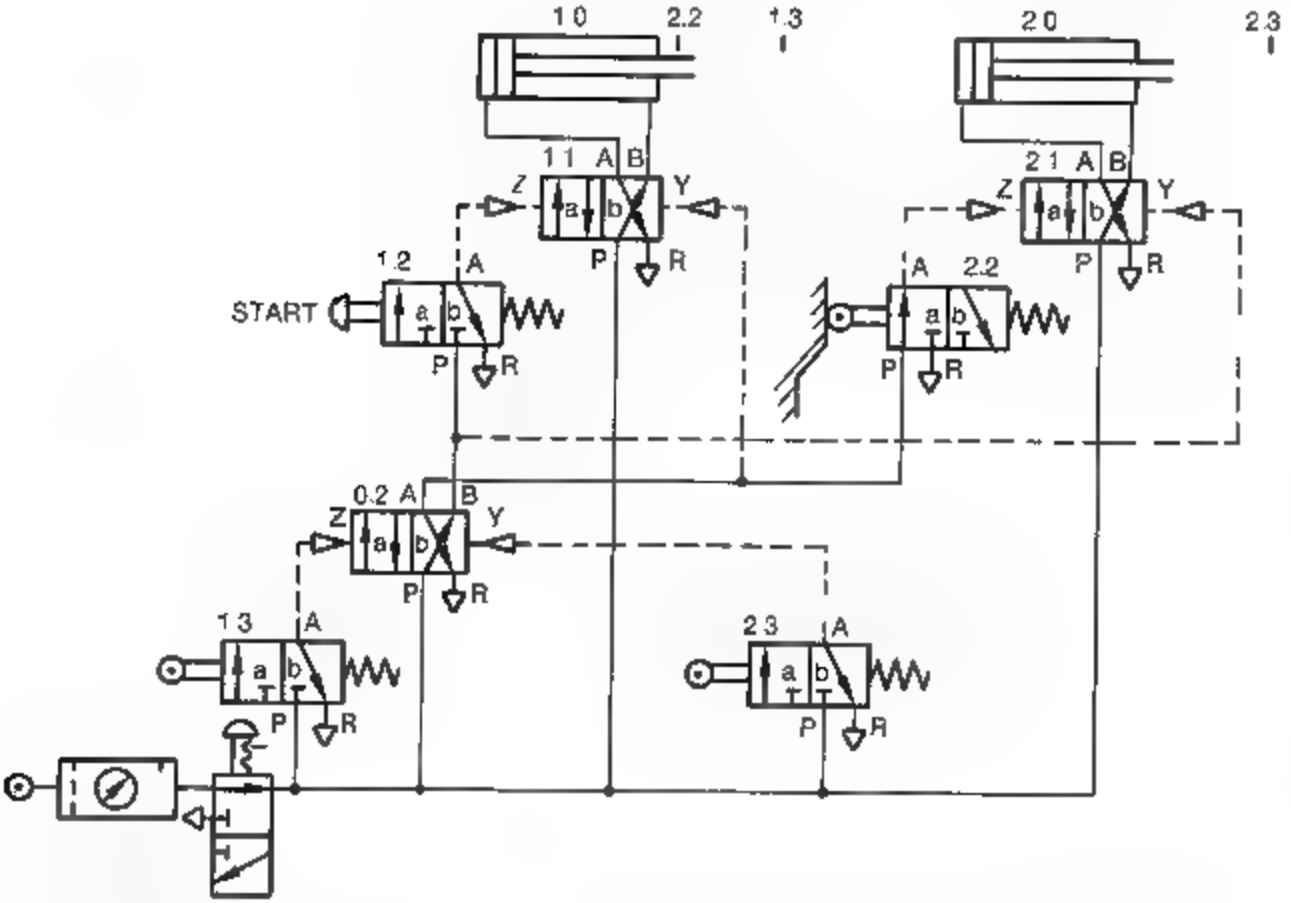
Problem

Metal sheets are to be flanged on a pneumatically operated bending tool. A first bend is to be made with one cylinder. When this has retracted, the part is completed by a second cylinder.

Idle return rollers may not be used in the circuit.

Position sketch





Procedure

1. Prepare the equipment
2. Build up according to the circuit diagram
3. Check the function by 1.2.
4. Dismantle, tidy up

Equipment

- [1] 2 double-acting cylinders
- [2] Three 4/2-way valves or 5/2-way valves (⊢▭/▭⊣)
- [3] Normally closed 3/2-way valve (⊄\W)
- [4] 3 normally closed 3/2-way valves (⊙⊏/W)

Test Questions to Exercise 17

Name: _____

Bending Tool

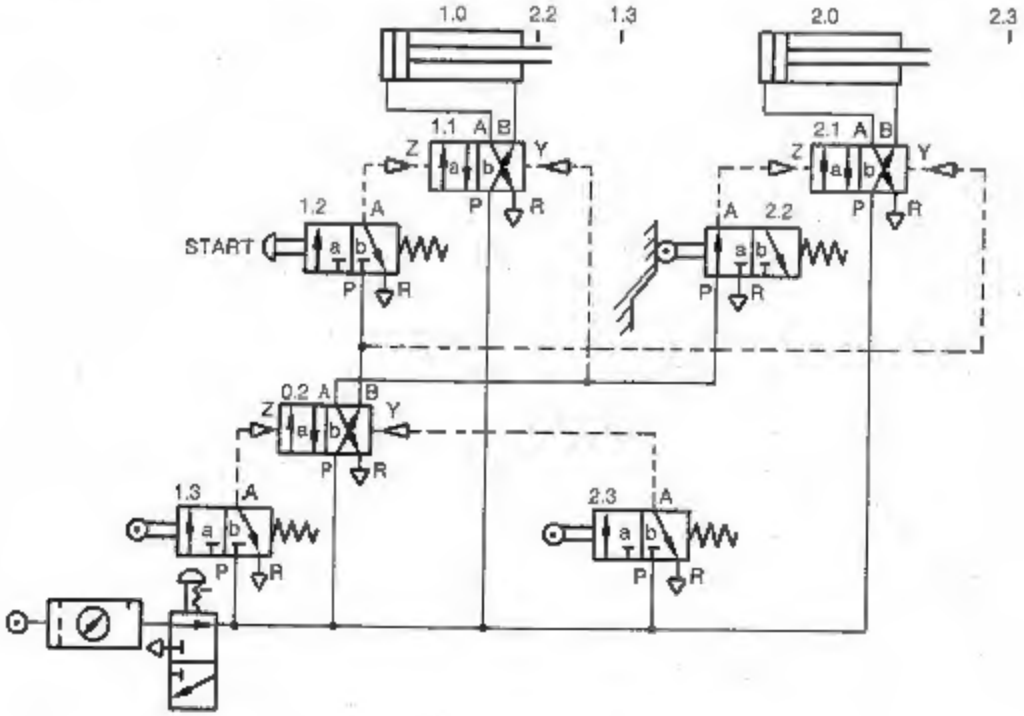
Date: _____

1. Name two methods of signal switch-off.

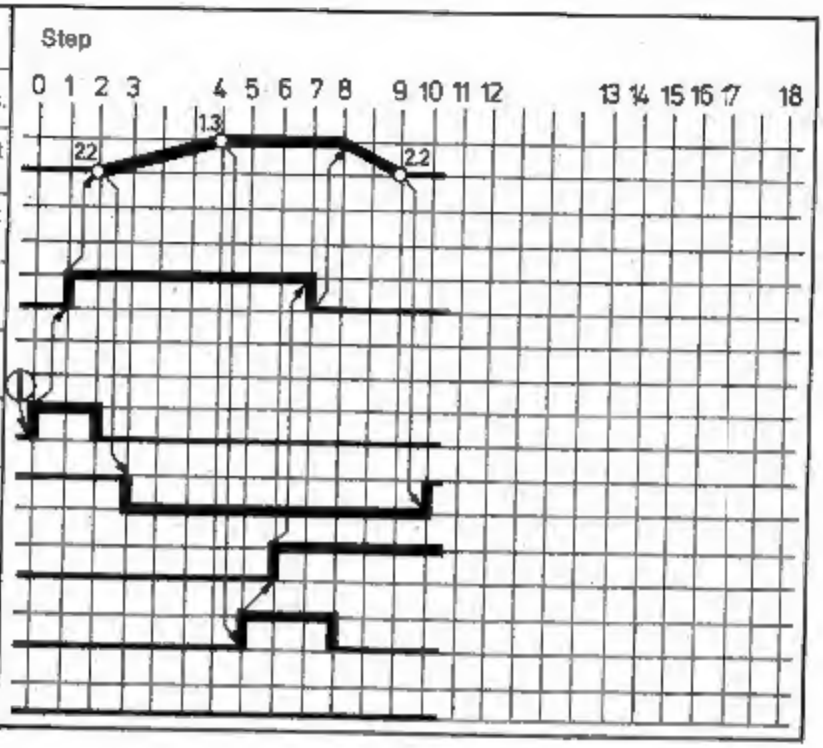
   a) .....

   b) .....

2. Draw the displacement-step diagram for this exercise until all devices are in their initial positions.



Component			State
Device No.	Name	Function	Pos.
1.0	Double-acting cylinder	Bend	Out In
2.0	Double-acting cylinder	Finish bend	Out In
1.1	4/2- or 5/2-way valve	Controls 1.0	a b
2.1	4/2- or 5/2-way valve	Controls 2.0	a b
1.2	3/2-way valve	START	a b
2.2	3/2-way valve	Controls 2.1	a b
0.2	4/2- or 5/2-way valve	Controls 1.1 2.1	a b
1.3	3/2-way valve	Controls 0.2	a b
2.3	3/2-way valve	Controls 0.2	a b



ISBN 3-8127-0051-4

A pneumatics course has been developed by the BBF, assisted by FESTO DIDACTIC, for vocational basic training. The student is to implement experimentally the knowledge imparted in the text book in exercises using the training table and the BBF construction kit; he thus learns through play. The level of knowledge attained can be checked at any time thanks to the tests given in the work book. In the manual for the instructor, further knowledge and examples are detailed.

Contents:
17 exercises
Single-acting cylinder
Double-acting cylinder
3/2, 4/2 and 5/2 way valves
Shutoff valves, pressure valves, flow control valves
Diagrams
Design of circuit diagrams
Practice examples based on practical tasks.